Concentrations and Chiral Signatures of Polychlorinated Biphenyls in Outdoor and Indoor Air and Soil in a Major U.K. Conurbation

ARSALAN JAMSHIDI, STUART HUNTER, SADEGH HAZRATI, AND STUART HARRAD*

Division of Environmental Health and Risk Management, Public Health Building, School of Geography, Earth, and Environmental Sciences, University of Birmingham, Birmingham B15 2TT, United Kingdom

Concentrations and chiral signatures of polychlorinated biphenyls (PCBs) were measured in outdoor air (using polyurethane foam (PUF) − disk passive samplers) and surface soil samples taken at approximately monthly intervals over 1 year at 10 locations on a rural−urban transect across the West Midlands of the U.K. In both air and soil, concentrations clearly decrease with increasing distance from the city center, supporting the existence of an urban "pulse", that indicate the West Midlands conurbation to be a source of PCBs to the wider environment. Concentrations of PCBs in outdoor air samples in this study are well below those reported previously for indoor air in the West Midlands. This, combined with comparison of chiral signatures in outdoor air and soil with those in samples of indoor air taken in the West Midlands, suggest strongly that the principal contemporary source of PCBs in this conurbation is ventilation of indoor air and not volatilization from soil. Future reductions in PCB concentrations in outdoor air and ultimately human exposure appear best achieved by action to remove remaining sources of PCBs from existing structures.

Introduction

Polychlorinated biphenyls (PCBs) have found widespread use in a diverse range of applications, with around 1.2 million tonnes produced worldwide (*1*). Approximately 67 000 and 40 000 t were produced and used, respectively, in the U.K. (*1*). Owing to concerns about their adverse effects on humans and wildlife, their production—but not use—ceased in the U.K. and most of the industrialized world in the late 1970s. Although U.K. human exposure to dioxin-like PCBs via the diet has fallen in recent years in response to cessation of their production (*2*, *3*), human health concerns remain—currently a substantial proportion of U.K. schoolchildren and toddlers are exposed via the diet at levels that exceed the U.K. government's recommended tolerable daily intake to dioxins and dioxin-like PCBs (*3*). Furthermore, we reported recently that concentrations of PCBs in indoor air in the U.K.'s West Midlands displayed no significant change over the past decade, remaining on average around 30 times above that outdoors and contributing an average of 30% of combined human exposure to ΣPCB via the diet and air (*4*).

In addition to direct impacts on human exposure, elevated concentrations of PCBs in indoor air have been hypothesized to help maintain contemporary outdoor air concentrations via ventilation (*5*). This is consistent with our recent comparison of chiral signatures of PCBs in bulk outdoor air and soil at one urban and one rural West Midlands location (*6*). While signatures in outdoor air were racemic, matching those in commercial PCB formulations, those in soil displayed appreciable enantioselective degradation. These data led us to hypothesize that volatilization from soil is not an important source of PCBs to bulk outdoor air at the two sites monitored (*6*). Given the policy implications of this hypothesis, it is important that it is tested elsewhere.

We reported recently spatial trends in concentrations of polybrominated diphenyl ethers (PBDEs) in outdoor air and soil at ten locations along an urban:rural transect in Birmingham (*7*). These data revealed an "urban pulse" with concentrations increasing with proximity to the urban center. Similar findings have been reported for both PBDEs and PCBs in the Greater Toronto conurbation (*8*). We attributed such "urban pulses" for PBDEs to the widespread indoor contamination by PBDE-treated goods that subsequently ventilate outdoors (*7*). Owing to the ongoing contamination of indoor environments with PCBs (*4*), we hypothesize a similar "urban pulse" will be observed along the same West Midlands urban−rural transect for PCBs.

Outdoor air and soil are important matrices to monitor. Air is important because atmospheric transport is the most efficient means of dispersing contaminants away from locations in which they were originally used, and soil is important because it constitutes the major terrestrial sink for PCBs in the U.K. (*1*). Furthermore, comparison of chiral signatures in air, soil, and grass suggests that although volatilization from soil does not influence bulk air, it does impact on air concentrations at the soil:air interface, therefore supplying PCBs to grass foliage (*9*), with consequent impacts on human exposure via foodstuffs derived from grazing animals.

This study reports concentrations of PCBs in outdoor air and surface soil taken on an approximately monthly basis from 10 locations on a 79 km urban−rural transect across the West Midlands. We also report chiral signatures of three atropisomeric PCBs, viz. congeners 95, 136, and 149 in the same samples. The direction of the transect corresponds with the prevailing wind direction—i.e. from the southwest (upwind) to the northeast (downwind)—affording a potential insight into the role of the heavily urbanized center as a source of PCBs to the wider environment. By covering distances from Birmingham city center of 48 km southwest to 31 km northeast with intersite distances of 3−17 km, spatial variation between a range of rural, suburban, and urban locations was studied.

Furthermore, we observed previously racemic or near-racemic signatures for PCB #s 95 and 149 in 20 samples of indoor air that match closely those in outdoor air, but not those in soil (*9*). This—combined with concentrations of PCBs in indoor air that exceed substantially those in outdoor air (*4*)—suggests that ventilation of indoor air is a far more significant contributor to outdoor air concentrations than volatilization of PCBs from soil. To further examine this, we report chiral signatures of PCB #s 95, 136, and 149 in a further set of 11 samples of indoor air taken within the West Midlands for which concentrations of PCBs have been previously reported (*4*).

* Corresponding author phone: +44 121 414 7298; fax: +44 121 414 3078; e-mail: S.J.Harrad@bham.ac.uk.

10.1021/es062218c CCC: $37.00
Published on Web 02/21/2007 PAGE EST: 5.7